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Photoluminescence of PbS in the Infrared

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The study of the infrared luminescence of substances has so far been limited to the spectral region between 0.8 and 1.2 μ. This is the region where it is possible to use photographic plates and electron-optical devices as receivers of radiation. The work of Khlebnikov and Melamid[1] is an exception. These authors found the luminescence of the antimony-cesium photocathode in the region of wavelengths above 1.2 μ, the luminescence being observed with irradiation of the photocathode in the wavelength region from 0.8 to 1.5 μ.

We made an experimental study of the photoluminescence of substances in the more remote infrared region. In these experiments we used as the receiver of radiation the photoconductivity of PbS, which has a range of sensitivity reaching approximately 3.5 μ.

For the excitation of luminescence, we used several spectral sections in the visible and ultraviolet regions of the spectrum of a mercury lamp of very high pressure; the resolution of the exciting light into the spectrum was done by means of a monochromator with water prisms. The radiation from the monochromator was modulated by a rotating disc with slots and was collected by a quartz lens on the sample being tested. The radiation emitted from the surface of the sample was in turn directed by a spherical mirror on the surface of the radiation receiver. Light filters (colored glasses IKS-3 and SZS-10, each 2 mm thick), which together completely absorbed the ultraviolet, the visible, and the near infrared (up to 1.3 μ) radiation, were placed in front of the receiver. The radiation of the lamp in the region of wavelengths longer than 1.3 μ was totally absorbed in the system of the monochromator, and therefore a system of crossed filters was formed. Thus, only when there was luminescence in the sample in the region of wavelengths longer than 1.3 μ could we get a modulated signal at the output of the system of receiver-amplifier-cathode ray oscillograph.

Testing various samples of PbS, we found that only samples having a noticeable internal photoelectric effect have a quite intense infrared luminescence in the above-mentioned spectral region during their exposure to visible and ultraviolet radiation. We found by means of an interference light filter, which passes a narrow spectral interval in the vicinity of 2.6 μ, that the infrared luminescence is quite intense in the region of the spectrum passed by the light filter.

To determine more precisely the region of photoluminescence, the samples were exposed to the radiation of a mercury lamp without spectral resolution, and the long wavelength radiation was cut off by a tube filled with water. The section of the sample, which was subjected to intense irradiation, was projected by means of a spherical mirror onto the slit of the monochromator

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with a prism of LiF. Scattered light was eliminated as before by placing glass light filters in the path of the beam. Using a PbS receiver, placed behind the exit slit of the monochromator, and a detecting system consisting of an amplifier and an oscillograph, we observed that at room temperature the photoluminescence of PbS lies in the wavelength region above 2 μ and that the maximum of the observed signal, under the above-mentioned conditions of illumination and detection of the infrared luminescence, is in the vicinity of 2.8 μ.

This phenomenon is very similar in many respects to the effect described previously by Loshkarev and Kosonogova,[2] who were the first to observe infrared luminescence in cuprous oxide samples, and is of interest for the physics of semiconductors.

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[1]N. S. Khlebnikov and A. Ye. Melamid, Doklady Akad. Nauk SSSR, 63, 649 (1948).
[2]V. Ye. Loshkarev and K. M. Kosonogova, Doklady Akad. Nauk SSSR, 54, 125 (1946).

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